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Title of the Invention

**COUPLING ASSEMBLY HAVING ENHANCED AXIAL TENSION
STRENGTH ~~AND METHOD~~ OF INSTALLATION OF COUPLED
UNDERGROUND DUCT**

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5 **BACKGROUND OF THE INVENTION**

FIELD OF THE INVENTION

This application claims the benefit under 35 U.S.C. 119(e) of United States Provisional Application Serial No. 60/071,159 filed January 12, 1998.

10 The present invention provides a coupling assembly for plastic pipe, and more particularly
a coupling assembly in which the coupled pipe has enhanced axial tension strength resulting in a
pipe and coupling connection that can withstand high axial loads in tension, and that require no
additional means for maintaining the coupling assembly in a coupled state. This coupling
assembly is particularly useful in applications that require that multiple coupled lengths of pipe be
pulled long distances through underground boreholes while maintaining a seal between the
coupled lengths of pipe without disconnecting. The present invention provides an inexpensive
plastic coupling assembly for conduit or pipe comprising a tubular component, a coupler, an
annular locking strap, and an annular sealing member, the combination being easy to assemble and
disassemble and allowing at least one thousand feet of such pipe to be pulled through an
underground borehole without the use of additional fasteners to maintain the coupled state.

20 **DESCRIPTION OF RELATED ART**

Fiber optic transmission lines and other cables have increasingly replaced metallic
electricity-conducting wires. For various reasons, it has been desirable to bury fiber optic cables,
utility cables and utility pipes underground. To protect the cables and pipes while underground,
the cables or pipes may be placed in a conduit or duct. See, e.g., U.S. Patent No. 5,027,864 to

Conti, et al. The cables may be placed in an inner duct, that, in turn, is pulled through a larger outer duct. See also U.S. Patent No. 5,087,153, to Washburn.

One preferred material for underground duct applications is PVC pipe or tubing, which is normally supplied in lengths of 4, 10 or 20 feet, but may be supplied in other lengths. Each such length of pipe must be coupled to adjacent lengths by means of a coupling assembly. A single 20 foot length of 4-inch PVC pipe weighs approximately 45 pounds. Thus, a tunnel one thousand feet long will require that some of the coupling assemblies bear an axial tensile force of at least several thousand pounds due to the combined effects of pipe weight, frictional drag resulting from the pipe walls contacting the walls of the borehole while the conduit is pulled, or contact with other obstructions. When this several thousand pounds is applied over the surface area contacted by a locking mechanism in a coupling assembly, the pressure borne by the locking portion of the coupling assembly may be close to the tensile strength of PVC. Previously known PVC coupling assemblies could not bear such loads, or required additional fasteners. Prior art augmentation of such coupling assemblies greatly increased the difficulty, expense and even danger of using coupled lengths of plastic pipe for such applications. Coupling assemblies made from other materials such as metal were unsatisfactory for reasons such as weight; limitations of the materials, such as the proneness to corrosion of some metals (e.g., aluminum or steel); or expense (e.g., stainless steel).

Continuous lengths of plastic tubing have been used for underground duct applications. The method for installing this type of conduit into a horizontal borehole is by pulling long lengths of the tubing from a spool through the borehole. The most often used plastic tubing is polyethylene ("PE"), supplied on large, heavy spools, each containing some 600 feet of tubing. Such tubing generally has a wall thickness of 0.320 inch in a four-inch diameter. While

inexpensive and widely available, PE tubing suffers from several drawbacks. Adjacent lengths must be butt sealed together by appropriate welding with a specialized apparatus. Both the tensile strength and crush resistance of PE tubing are less than that of a material such as PVC pipe. Such tubing frequently suffers from increased ovality due to the flattening effect of being coiled on the spool. A contractor installing the tubing must feed each spool from a specially designed apparatus, upon which each spool must be mounted in turn. When the end of the spooled tubing is released, it can dangerously whip around, potentially causing serious injury to workers and others. In a related effect, PE has a considerable "memory" of the curvature it has been forced to adopt while on the spool, as a result of which the PE tubing retains a strong tendency to curl after it is removed from the spool. Finally, tubing is often wasted if the length of the borehole does not equal the length of a multiple number of spools of tubing.

PVC pipe lengths have several advantages over continuous lengths of coiled tubing. With PVC pipe, the exact number of lengths needed for a job can be stacked together and delivered in an ordinary flatbed truck minimizing time, manpower, equipment and wasted material. PVC pipe has greater tensile strength and crush resistance than polyethylene tubing, and has better resistance to developing ovality. Because the lengths have not been forced to bend prior to use, they do not suffer from "memory" problems found with PE tubing.

Use of PVC pipe has not been without disadvantages. Previously known PVC pipe couplings typically required augmentation. Thus, numerous steps were performed in prior art methods to assemble the coupled lengths of PVC pipe. One method requires cementing the joint together after it is assembled. The typical coupling for such PVC pipe is a bell and spigot type coupling, in which each length of pipe has one end slightly belled outward (the coupler) and the other end not belled (the tubular component). The belled end is enlarged to a degree sufficient to

allow a non-belled end of an adjacent length to enter, forming a sealed coupling when properly cemented together.

The cementing process includes all the known difficulties associated with PVC cement, including the use of noxious, hazardous solvents and the time required for the PVC cement to cure. The most serious drawback of this type of glued-together coupling for use in applications requiring installation by pulling through a substantially horizontal borehole is the lack of resistance to axially applied tension when in the coupled state. This drawback has only previously been overcome by augmenting the PVC cement with other fastening means, typically radially inserted screws. In order to securely attach the lengths together, screws such as self-tapping metal screws are inserted radially into the coupling assembly adding an additional step, equipment, and personnel. But, even with this improvement, additional time for the glue to cure is needed in advance of the time when the pipe is to be pulled through the tunnel. As a result, it is normally necessary to pre-assemble several hundred feet or the entire string of glued- and screwed-together PVC pipe, before the pulling process can be started.

An additional drawback of using bell and spigot coupling assemblies results from the diameter of the bell end, which is larger than the remainder of the pipe. This increased diameter makes the installation of the pipe through the underground borehole more difficult due to increase drag especially when rocks, roots, or other obstructions are encountered. The screw heads also increase the installation difficulties because they extend radially outwardly from the bell further increasing the outside diameter of this portion of the pipe and provide a location for encountering snags with obstructions.

The present invention provides a simpler, stronger, and easier to assemble coupling assembly than any known heretofore.

SUMMARY OF THE INVENTION

A major difficulty that must be overcome when pulling any duct through an underground borehole or other passage is the high axial tension the duct and its coupling assemblies must withstand. This is particularly true for lengths of duct held in the coupled state by known coupling assemblies. The present invention provides an inexpensive plastic coupling assembly for conduit or pipe, comprising a first coupling member, a second coupling member and a locking member. The first coupling member is optionally a tubular component and the second coupling member or coupler is optionally a belled component. The present invention is also optionally provided with an annular sealing member. The combination is easy to assemble and disassemble and allows at least one thousand feet of such pipe to be pulled through an underground borehole without the use of additional fasteners to maintain the coupled state. The coupling assembly may be assembled without the use of tools by manually inserting the tubular component into the coupler and then inserting the locking strap into a slot and into a locking strap passageway. The coupling assembly may be disassembled without the use of tools by performing the installation sequence in reversed order. When assembled, the locking strap is disposed in a locking position between the coupler and the tubular component and the annular sealing member is disposed in a sealing position between the coupler and the tubular component. The coupling assembly remains locked and sealed when subjected to high axial pulling forces. The coupling assembly of the present invention requires no augmentation to its strength for axial tension, the locking strap providing sufficient strength when in its locking position that no additional fasteners or glue are needed to maintain the coupling assembly in the coupled state.

The coupling assembly of the present invention further provides a smooth, obstruction-free inner surface and a relatively smooth outer surface. The outer surface is generally convex,

although it preferably has a central constant-diameter portion. The outside diameter of the coupler is only slightly greater than the diameter of the pipe or tubular component, and the outside diameter of the coupler tapers to a smaller diameter toward the end of the coupler. The coupling is therefore relatively smooth and avoids the possibility of snags or excessive frictional interactions with the walls of or obstructions within the borehole through which the pipe is installed.

The preferred coupler has an inner surface that includes a groove used in locking the coupling assembly together, a stop surface used to prevent over-insertion of the tubular component, and a groove for an annular seal.

The coupling assembly of the present invention further provides high strength against lateral forces tending to bend the coupling assembly and result in breakage of either the locking or sealing function. This strength derives from the depth of insertion of the tubular component into the coupler and from the strength of the materials of construction of the coupler, and the relative positions of the locking ring and sealing member. The method of the invention is simpler than previously known methods, due to the advantages of the present invention.

As will be appreciated, the invention is capable of other and different embodiments, and its several details are capable of modifications in various respect, all without departing from the spirit of the invention. Accordingly, the drawings and description of the preferred embodiment are to be regarded as illustrative in nature and not restrictive.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention satisfies the needs noted above as will become apparent from the following description when read in conjunction with the accompanying drawings wherein:

FIG. 1 is a view of a preferred conduit having the coupling elements that form the coupling assembly of the present invention.

FIG. 2 is a view of a preferred coupler component.

FIG. 3 is a view of a preferred locking key.

FIG. 4 is a view of a preferred sealing member.

FIG. 5 is a view of a preferred conduit assembly with an installed locking key.

FIG. 6 is a view of a preferred tubular component.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The following description is made with reference to the drawings. As shown in Figures 1-6, the preferred coupling assembly of the present invention includes a coupler 12, a tubular component 14, a locking key 16, and an annular sealing member, such as annular sealing seal 18. The coupling assembly is designed to assemble easily and by hand, but to strongly resist both high axial tension and high lateral stress.

The coupler 12 is formed at one end of a section of the tubing and has an inner surface 20, an outer surface 22, and a pipe wall 72. The coupler 12 has a curved region 24 at which both the inner diameter ("ID") and the outer diameter ("OD") of the curved region 24 gradually increase until the inner diameter of curved region 24 exceeds the outer diameter of the tubular portion of the coupler 12. Resistance to snags on roots and rocks is greater on the pipe coupling according to this invention due to the gradual transition of the coupler OD. The prior art coupling design offers no transition, but has a 90 degree edge that is from 0.5 to 0.75 inches high per side. The coupling of this invention makes a minor .25 inch transition over approximately 1.5 inches. The

inner surface 20 of the curved region 24 also provides a stop surface 70 to prevent over insertion of the tubular component 14.

The curved region 24 terminates into a slightly tapered region 26. The slightly tapered region 26 is provided with a seal groove 28 and a locking strap groove 30 on inner surface 20.

5 Seal groove 28 is shallow, approximately .07 to .08 inches, allowing for a thicker pipe wall 72 and the resultant increase in tensile strength of the pipe joint. This is critical because the seal groove 28 is one of the weakest areas of the pipe joint in pure tensile strength loading. Even with the thicker pipe wall, the OD of the coupler 12 can be made smaller, nominally 5.0 inches, compared to the competing coupled pipe design that are 5.5 or 6.0 inches in diameter. The reduced OD allows for the drilling of a smaller hole for installation of the pipe thus reducing installation cost based on reduced drilling time and labor.

The slightly tapered region 26 of the most preferred embodiment is at least approximately 6 inches in length that enables greater engagement and depth of overlap of the coupling 12 compared to the prior art devices. Engagement and depth of overlap of the pipe joints has direct impact on the strength of the joint while being bent. Analysis indicates that lower overlap results in a significant decrease in the ability of the joint to withstand bending. The competing design has only 4 inches of engagement of the pipe.

Coupler 12 is also provided with a slot 54 in region 26 that extend from outer surface 22 to locking strap groove 30 on inner surface 20. Slot 54 is formed tangent to the centerline of locking strap groove 30.

The tubular component 14 is formed at the other end of the tubing. The tubular component 14 has an inner surface 32 and an outer surface 34. Outer surface 34 is provided with a locking strap recess 36. Locking strap recess 36 is provided with a wider width than locking



strap groove 30 to provide an adjustability feature enabling the insertion of locking strap 16 without further positioning of tubular component 14 and coupler 12. When the tubular component 14 is installed in coupler 12, the locking strap recess 36 is opposite locking strap groove 30 to form locking strap passageway. The tubular component 14 is also provided with a beveled or chamfered end surface 38 adjacent the tube end 74. The preferred tubular component 14 is constructed from a thermoplastic material.

The locking strap 16 is made of any plastic material possessing sufficient tensile strength to withstand the pressure exerted on the pipe such as nylon and includes a handle portion 40 and a body portion 42. Handle portion 40 is permanently attached to one end of body portion 42 and is provided with a grip portion 44 that is attached approximately perpendicular to body portion 42 to aid in inserting and de-installing the locking strap 16. Body portion 42 has a first reduced thickness area 46 at a handle end 48 and a second reduced thickness area 50 at forward insertion end 52. Reduced thickness areas 46, 50 have half the cross section width of the full section of the remainder of the locking strap 16. This reduction of the cross section enables the overlapping of the ends 48, 52 of the locking strap 16 to bear the load of the entire circumference of the engagement between the locking strap 16 and the mating locking strap groove 30 and locking strap recess 36. This is necessary because when the locking strap 16 passes through the slot 54 of the coupler 12 and into the locking strap passageway, there would be a loss of engagement with a portion of the passageway. To eliminate this loss of engagement and to construct a stronger joint, the reduced spline cross section enables the overlap of the ends of the spline. The performance of ultimate tensile pull increases by as a result.

The coupling assembly is also provided with an annular sealing member, such as annular sealing seal 18. Seal 18 is has an upper surface 56 and a lower surface 58 and is generally

rectangular in cross-section. Both the upper surface 56 and lower surface 58 are provided each with three sealing lobes 60. Each sealing lobe 60 forms a separate sealing surface when seal 18 is installed in the coupling assembly as compared to only one sealing surface if a seal with another cross-section, such as circular or rectangular, was used. The cross-sectional dimensions of seal 18 are small, approximately .200 inches by .122 inches in the most preferred embodiment but other dimensions could be used, enabling the load bearing pipe wall thickness to be maximized due to the multiple sealing lobes, without compromising sealing functionality. The minimized cross-sectional dimensions of seal 18 also allow seal groove 28 to be shallow, allowing for a thicker pipe wall 72 and the resultant increase in tensile strength of the pipe joint. This is critical because the seal groove 28 is one of the weakest areas of the pipe joint in pure tensile strength loading.

If a circular cross-sectional seal was used, as in similar competing products, and the wall thickness of the coupling remained the same, the diameter of the pipe would have to increase. This would require that a larger hole be drilled in the earth resulting in increased installation costs due to increased incremental drilling time and labor. The OD of the pipe coupling in the most preferred embodiment is nominally 5.0 inches and could be less compared to 5.5 to 6.0 inches of prior art coupled pipe designs.

Moreover, if the circular cross sectional seal was used, the insertion force would increase, requiring the use of tools to assemble the pipe joint. Insertion forces for the coupling of this invention are about a fourth of what it would be if a circular cross sectional seal were used thus enabling the joint to be assembled without tools. In the event disassembly of the joint is required, the low compression and drag of the seal 18 on the pipe allow disassembly of the joint without tools.

To assemble the pipe coupling, seal 18 is placed into seal groove 28 of coupler 12 of a first tube. Tubular component 14 of a second tube is then inserted into coupler 12 of the first tube. Tubular component 14 is inserted until chamfered surface 38 rests against the inner surface of curved transition region 24. Seal 18 does not provide too much resistance during the insertion of tubular component 14 because of its reduced cross-sectional dimensions but forms an effective seal due to its multiple lobes 60 pressing against the outer surface 34 of tubular component 14. When fully inserted, chamfered surface 38 rests against the inner surface of curved transition region 24. Locking strap recess 36 of tubular component 14 aligns with locking strap groove 30 of coupler 12 to form a locking strap passageway. Locking strap recess 36 may be provided wider than groove 30 to allow some degree of adjustability. The two pipes are now in position for locking. The forward end 52 of locking strap 16 is inserted through slot 54 on coupler 12. Locking strap 16 passes through the slot 54 and is received into locking strap passageway. Locking strap 16 is completely inserted causing forward end 52 to overlap with handle end 48 and the handle 40 to abut against the outer surface 22 of coupler 12 creating a strengthened coupling.

If disassembly of the pipe coupling is needed, this can be accomplished without resort to tools. Handle 40 can be grasped to pull locking strap 16 out of locking strap passageway. Because of the slight adjustability of the pipe coupling due to the recess 36 being slightly wider than groove 30, tubes on either side of the coupling can be moved away from the coupling and also due to the decreased cross-section of the seal, the pipe coupling can be separated.

The coupling assembly of this invention may be favorably used with pipes made from a variety of materials, including a metal or a thermoplastic or a thermoset plastic. For practical reasons this invention is particularly useful in pipes made from thermoset plastic materials, such as



ethylene, ethylene-propylene copolymers and others, but especially PVC. In principal, however, the coupling assembly may be conveniently used with thermoset plastic pipes.

Having described in detail the preferred embodiment of the present invention, it is to be understood that this invention could be carried out with different elements and steps. This

5 preferred embodiment is presented only by way of example and is not meant to limit the scope of the present invention which is defined by the following claims.

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